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(54) An opto-electronic transmission system

(57) An opto-electronic transmission system has several subscribers coupled to an optical conductor ring bus, each subscriber having an optical branching device (3) for dividing the incoming optical signal into two portions (ϕ_{E1} and ϕ_{E2}), a receiving part (5) for converting one of the two portions (ϕ_{E1}) into an electrical signal, a pulse shaper (44) for regenerating the electrical signal, a transmission part (22) for converting the regenerated electrical signal into an optical signal (ϕ_{A1}) and supplying the optical signal (ϕ_{A1}) to the optical conductor ring bus for passing to the next subscriber, means (30) in the optical branching device (3) for attenuating the other optical signal portion (ϕ_{A2}) on to the optical signal (ϕ_{A1}) transmitted by the transmission part (22).

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SPECIFICATION NO 2073877A

The following corrections were allowed under Section 117 on 4 May 1984:

Front page, Heading (71) Applicant *for* Hartmann & Braus AG *read* Hartmann & Braun AG

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5 June 1984

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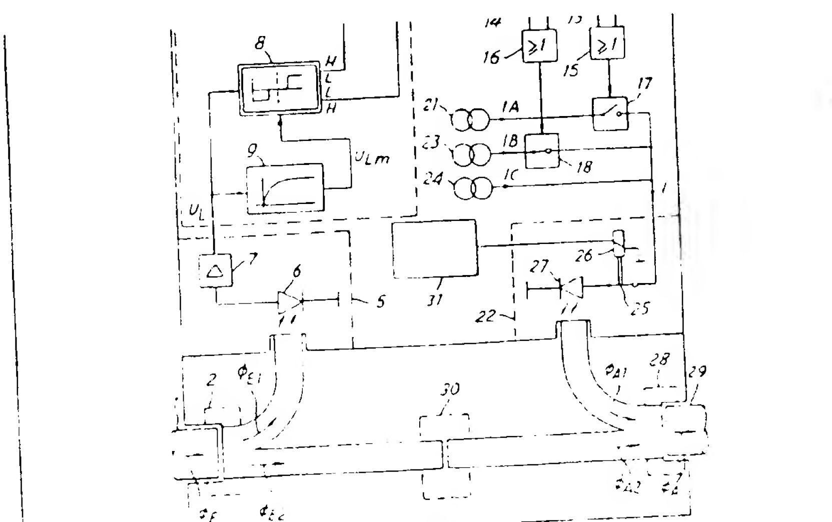

Fig 1

The drawings originally filed were informal and the print here reproduced is taken from a later filed formal copy.

POOR QUALITY

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(54) **An opto-electronic transmission system**

(57) An opto-electronic transmission system has several subscribers coupled to an optical conductor ring bus, each subscriber having an optical branching device (3) for dividing the incoming optical signal into two portions (ϕ_{E1} and ϕ_{E2}), a receiving part (5) for converting one of the two portions (ϕ_{E1}) into an electrical signal, a pulse shaper (44) for regenerating the electrical signal, a transmission part (22) for converting the regenerated electrical signal into an optical signal (ϕ_{A1}) and supplying the optical signal (ϕ_{A1}) to the optical conductor ring bus for passing to the next subscriber, means (30) in the optical branching device (3) for attenuating the other optical signal portion (ϕ_{E2}) and means for superimposing the attenuated optical signal portion (ϕ_{A2}) on to the optical signal (ϕ_{A1}) transmitted by the transmission part (22).

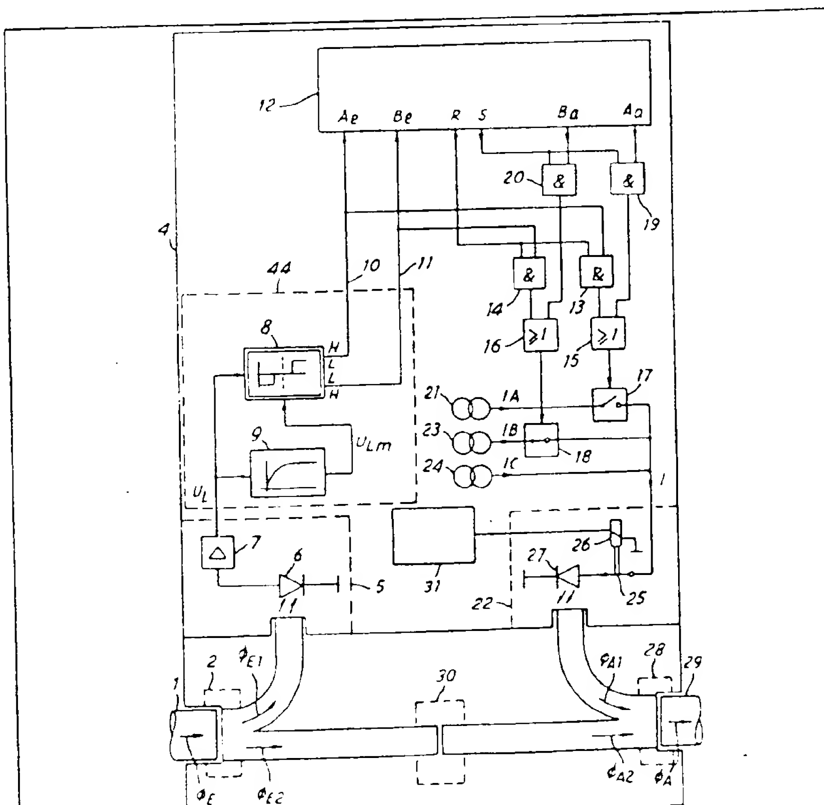

FIG 1

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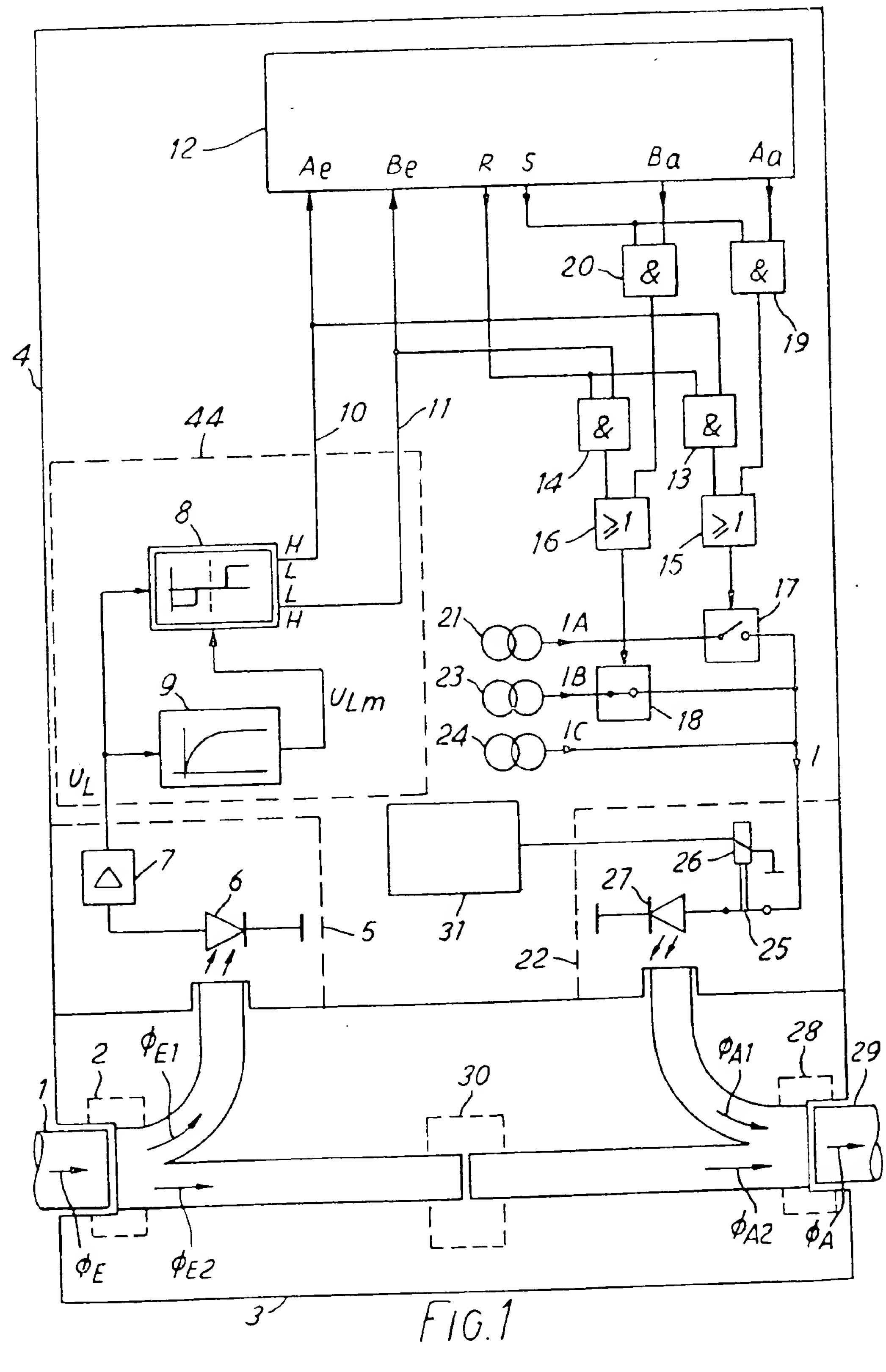
12
Ae
Be
R
S
Ba
Aa
20
&
&
19
4
44
10
11
&
&
14
13
≥1
≥1
16
15
8
H
L
L
H
17
21
IA
23
IB
18
24
IC
9
U_{Lm}
U_L
I
7
6
5
31
26
27
25
22
2
ϕ_{E1}
1
30
ϕ_{A1}
28
29
ϕ_E
ϕ_{E2}
ϕ_{A2}
ϕ_A
3

FIG.1

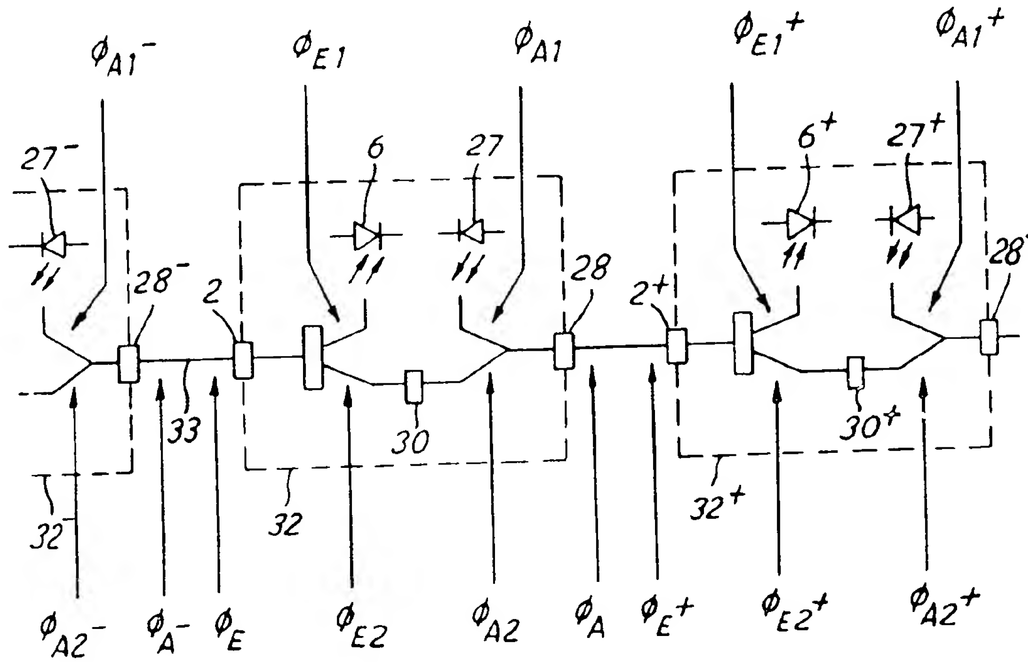
ØA1-
ØE1
ØA1
ØE1+
ØA1+
27-
6
27
6+
27+
28-
2
28
2+
28+
33
30
30+
32-
32
32+
ØA2-
ØA-
ØE
ØE2
ØA2
ØA
ØE+
ØE2+
ØA2+

FIG. 2

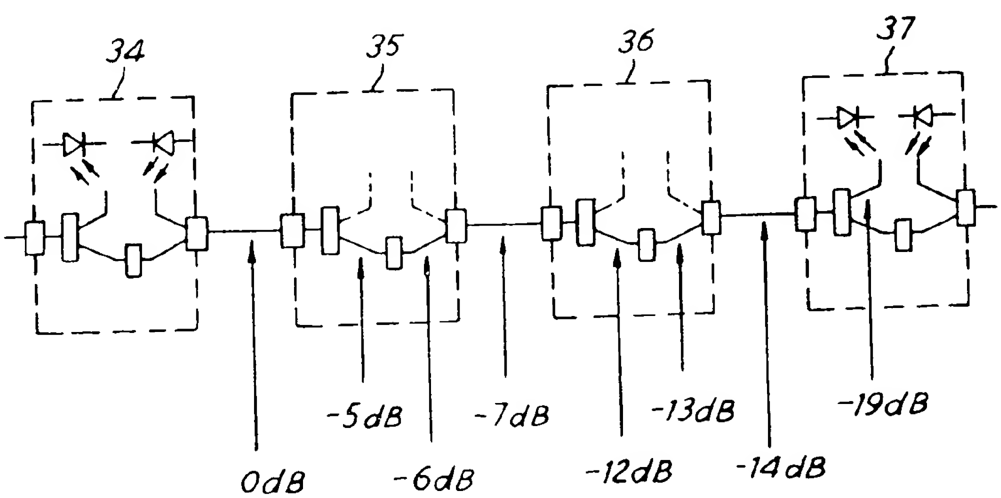
34
35
36
37
-5dB
-7dB
-13dB
-19dB
0dB
-6dB
-12dB
-14dB

FIG. 4

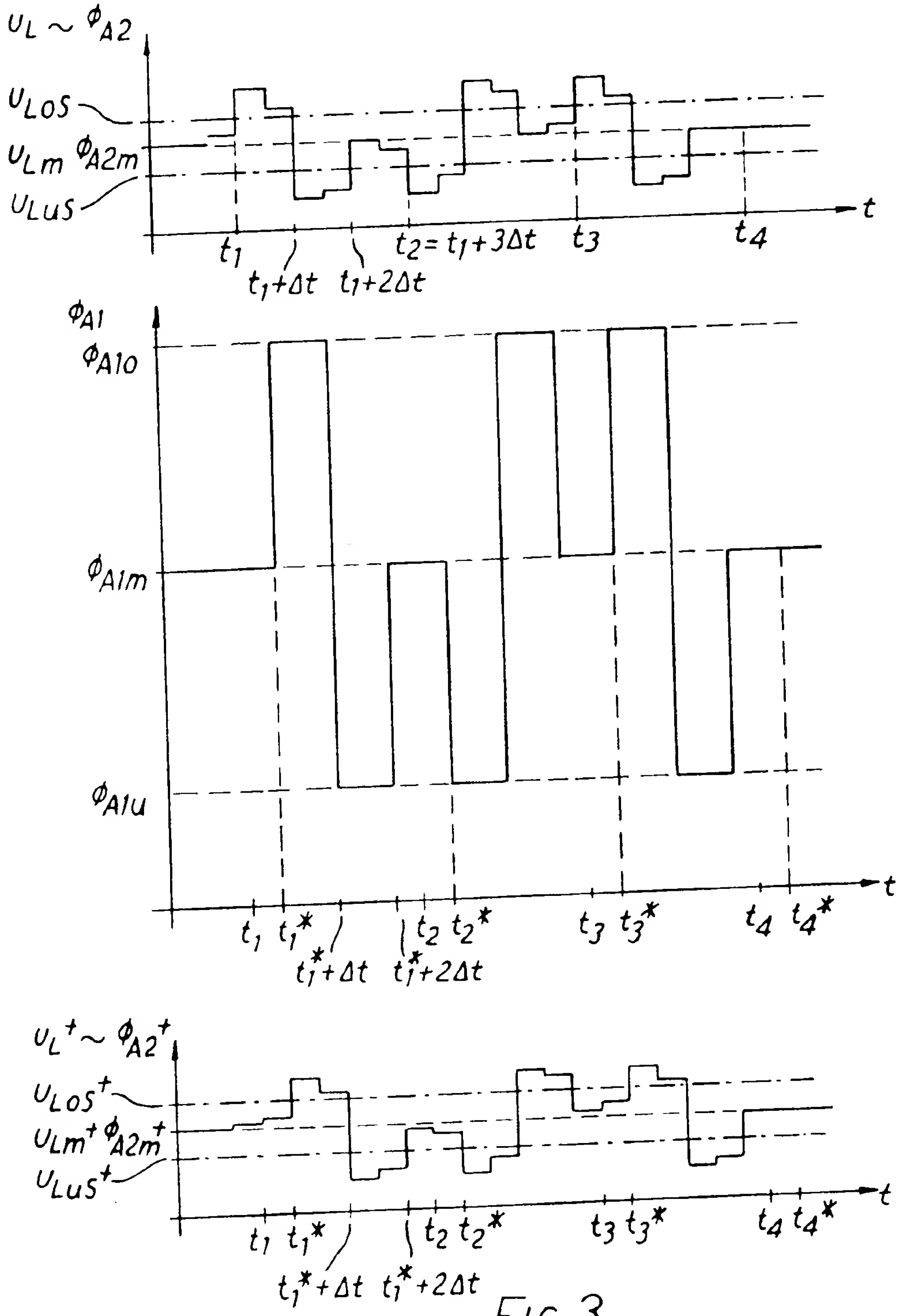
$U_L \sim \phi_{A2}$
U_{Los}
U_{Lm} ϕ_{A2m}
U_{Lus}
t
t_1
$t_1+\Delta t$
$t_1+2\Delta t$
$t_2=t_1+3\Delta t$
t_3
t_4
ϕ_{A1}
ϕ_{A1o}
ϕ_{A1m}
ϕ_{A1u}
t_1^*
$t_1^*+\Delta t$
$t_1^*+2\Delta t$
t_2
t_2^*
t_3^*
t_4^*
$U_L^+ \sim \phi_{A2}^+$
U_{Los}^+
U_{Lm}^+ ϕ_{A2m}^+
U_{Lus}^+

FIG. 3

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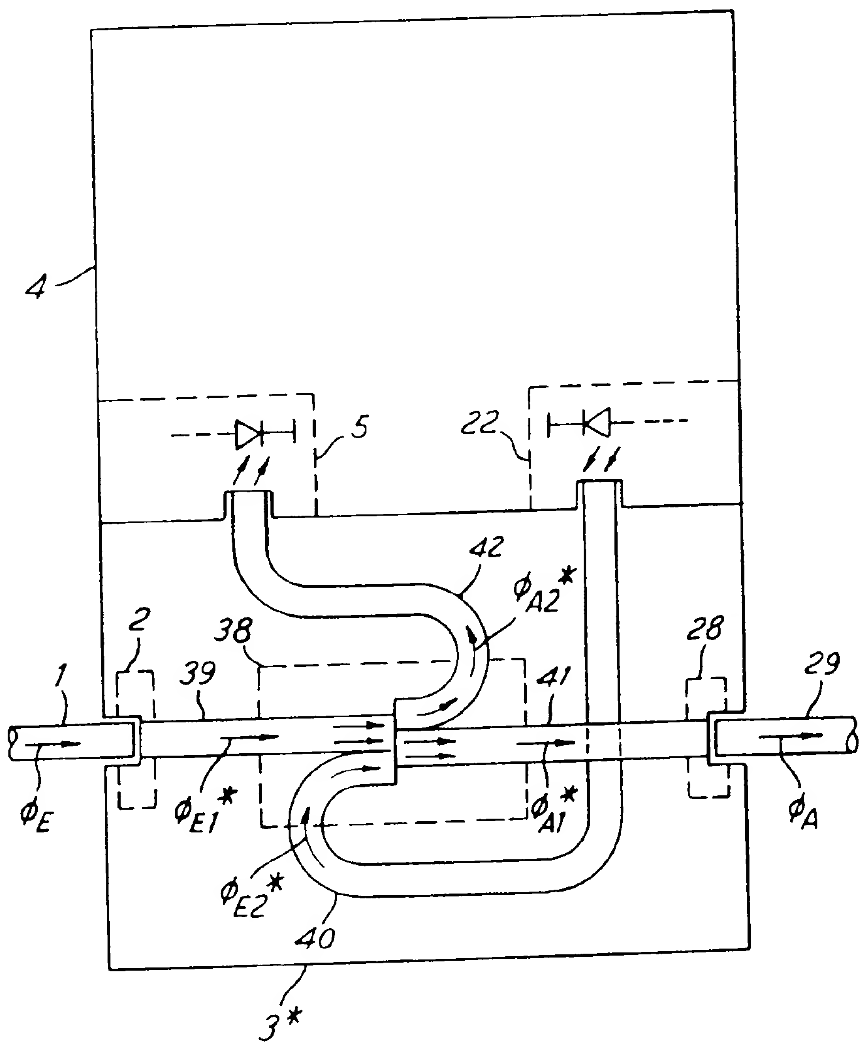

FIG. 5

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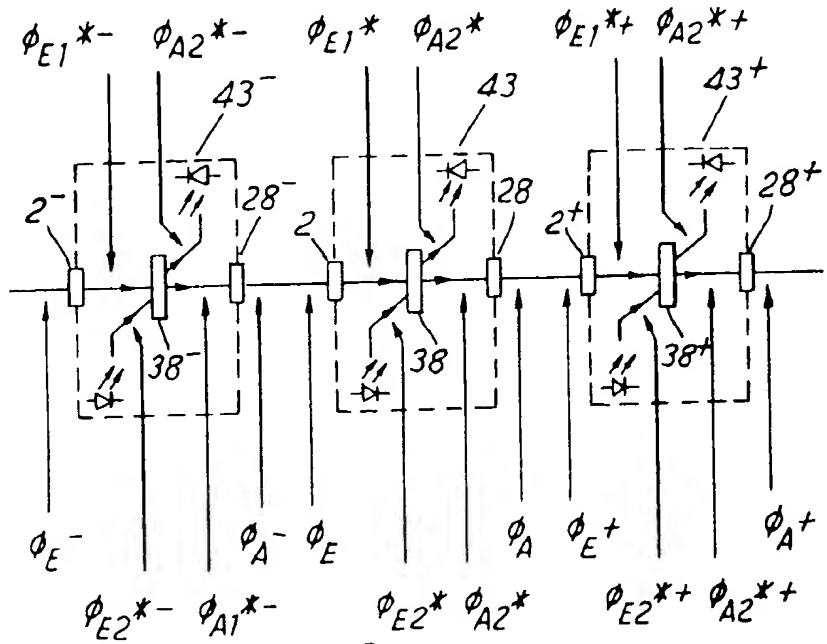

FIG.6

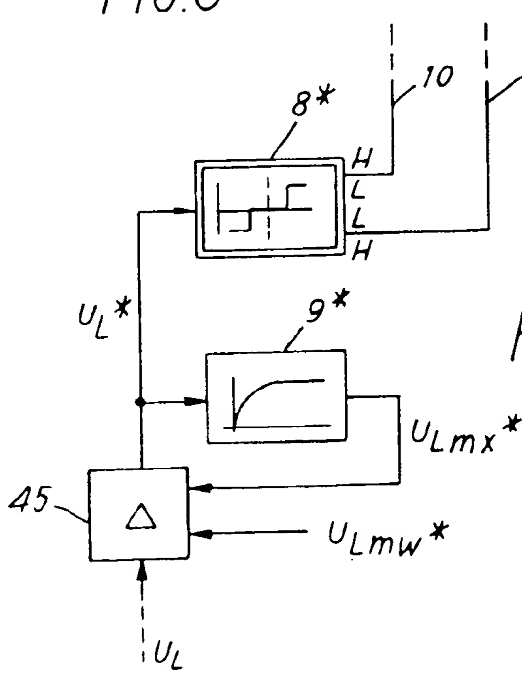

FIG.7

SPECIFICATION

Opto-electronic transmission system

The invention relates to an opto-electronic transmission system with several subscribers coupled to a ring bus of an optical conductor, each subscriber having an optical branching device for dividing the incoming optical signal into two portions, a receiving part for converting one of the two portions into an electrical signal, a pulse shaper for regenerating the electrical signals and a transmission part for converting the regenerated electrical signal into an optical signal and supplying the optical signal to the optical conductor ring bus for passing to the next subscriber.

Such a transmission system is known from European Patent Specification 0 002 971. Several subscribers are coupled to an optical conductor ring bus. The subscribers arranged between a transmitting subscriber and the receiving subscriber each regenerate the optical signal which they have received. In order that the transmission system should remain operational when subscribers fail, each subscriber contains an optical line of connection with an electrically controllable optical closure device which passes the optical signal direct to the next subscriber, i.e. without regenerating it, when the subscriber fails. If the subscriber is operational on the other hand, then the closure device is closed and the optical signal is converted into an electrical signal, the electrical signal is regenerated and the regenerated electrical signal is converted back into an optical signal which is supplied to the next subscriber. A. d.c. voltage of approximately V is required for driving the optical closure device.

The invention seeks to create an opto-electrical transmission system of the type stated at the outset which does not require an optical closure device which is controlled electrically.

According to the invention, there is provided an opto-electronic transmission system with several subscribers coupled to an optical conductor ring bus, each subscriber having an optical branching device for dividing the incoming optical signal into two portions, a receiving part for converting one of the two portions into an electrical signal, a pulse shaper for regenerating the electrical signals and a transmission part for converting the regenerated electrical signal into an optical signal and supplying the optical signal to the optical conductor ring bus for passing to the next subscriber, wherein the optical branching device attenuates the other signal portion and superimposes it on the optical signal tansmitted by the transmission part.

Further according to the invention there is provided an opto-electronic transmission system with several subscribers coupled to an optical conductor ring bus, these subscribers subdividing the incoming signal into two signal portions in an optical branching device; converting one of the two optical signal portions into an electrical signal in a receiving section; regenerating the electrical signal in a pulse shaper stage; converting the regenerated electrical signal into an optical signal in a transmission section and supplying it to the optical conductor ring bus for the purpose of passing it on to the next subscriber; the said opto-electronic transmission system continuing to be capable of operation when there is a fault in individual subscribers, wherein the optical branching device attenuates the other signal portion and superimposes it on the optical signal transmitted by the transmission part of the subscriber; a code is used for coding the information which is to be transmitted, which has three switching conditions with a constant arithmetic mean value and the pulse shaper stage compares the electrical signal emitted by the receiving part with two different threshold values one of which is selected so that it is larger and the other of which is selected so that it is smaller than the arithmetic mean value of the electrical signal, and the ratio between the arithmetic means value and each of the two threshold values is held constant.

The invention will now be described in greater detail by way of example with reference to the drawings in which:

Figure 1 shows the general view of a subscriber having a first optional branching device;

Figure 2 shows three subscribers connected by the ring bus of the optical conductor in schematic view in accordance with Fig. 1;

Figure 3 shows line diagrams of signal from a subscriber which is not faulty;

Figure 4 shows four subscribers connected by one optical conductor ring bus in schematic view according to Fig. 1 in which two successive subscribers are faulty;

Figure 5 shows a general view of a subscriber having a second optical branching device;

Figure 6 shows three subscribers connected by the optical conductor ring bus in schematic view according to Fig. 5, and

Figure 7 shows the general circuit diagram of a pulse shaper stage having automatic control of amplification.

The same components have been given the same reference symbols.

Fig. 1 shows a general view of one of the subscribers coupled to an optical conductor ring bus of an opto-electronic transmission system. The incoming end 1 of the optical conductor ring bus is connected to the optical part 3 of the subscriber via an optical plug connection 2. The incoming optical signal ϕ_E is attenuated in the optical plug connection 2 while in the following it

is assumed that this attenuation amounts to 1 dB. The optical signal which has been attenuated by 1 dB then subdivides into two signal parts ϕ_{E1} and ϕ_{E2} which are of equal size. The optical signal part ϕ_{E1} is supplied to the receiving part 5 which is associated with the electronic part 4 of the subscriber in Figs. 1 and 5. The receiving section 5 contains an opto-electronic converter 6 and an amplifier 7 which convert the optical signal part ϕ_{E1} into a proportional electrical voltage U_L. The electrical voltage U_L is supplied to a three state switch 8 and a delay element 9 which forms the arithmetic mean value U_{Lm} of the voltage U_L. The lower and upper thresholds of the three state switch 8 are designated U_{LuS} and U_{LoS} respectively. Both of the threshold values are in a fixed ratio to the arithmetic mean value, while one threshold value is smaller and the other larger than the arithmetic mean value. The two outputs of the three state switch 8 are connected to a circuit arrangement 12 via lines 10 and 11, the circuit arrangement 12 evaluating the information supplied to the subscriber. The signal on the line 10 is designated A_e and the signal on the line 11 is designated B_e, while their level values are designated either L or H. The three switching conditions of the three state switch 8 are shown in the following Table as a function of the voltage U_L:

	A_e	B_e
$U_L < U_{LuS}$	L	H
$U_{LuS} < U_L < U_{LoS}$	L	L
$U_L > U_{LoS}$	H	L

If the optical signal received is to be passed on, the signal R emitted by the circuit arrangement 12 has the level value H and the signal S has the level value L. The signals A_e and B_e are supplied via AND-gates 13 or 14 and OR-gates 15 or 16 to the control inputs of electronic switches 17 or 18 in this mode of operation. The signals A_s and B_s on the other hand are not passed on, since the output signal of the AND-gates 19 and 20 has the level value L because of the level value L of the signal S. The electronic switch 17 connects a first current source 21 to the transmission part 22 which in this case is assigned together with the receiving part 5 to the electronic part 4 of the subscriber. The electronic switch 18 connects a second current source 23 to the transmission part 22 and a third current source 24 is always connected to the transmission part 22. The electronic switch 17 is closed if the level value H is present at its control input and the electronic switch 18 is closed if the level value L is present at its control input. If the signals R and S have the level value L, then the electronic switch 17 is opened and the electronic switch 18 is closed.

The overall current I supplied to the transmission part 22 flows through the contact 25 of a relay 26 and through a light emitting diode 27 which produces an optical signal ϕ_{A1}, which corresponds to the overall current I which is flowing in each case and leads it via a further optical plug connection 28 into the outgoing end 29 of the optical conductor ring bus.

In the following it is assumed that in the optical plug connection 28 the signal is attenuated by 1 dB, as it is in the optical plug connection 2. The optical signal part ϕ_{E2} is supplied to the optical plug connection 28, via an optical connecting element 30 in the form of optical signal ϕ_{A2}. The optical signal ϕ_A in the outgoing end 29 of the optical conductor ring bus is formed by superimposing the optical signals ϕ_{A1} and ϕ_{A2} while taking the attenuation due to the optical plug connection 28 into account. In the case of faults in the electronic part 4 of the subscriber, a device 31 for detecting faults opens the contact 25 by means of the relay 26 and the optical signal ϕ_{A1} becomes zero.

If the subscriber is to operate in transmission, then the signal R emitted by the circuit arrangement 12 has the level value L and the signal S has the level value H. In this mode of operation, the signals A_s and B_s are supplied via the AND-gates 19 or 20 respectively and the OR-gates 15 or 16 respectively to the control inputs of the electronic switches 17 or 18 respectively. The signals A_e and B_e on the other hand are not passed on, since the output signals of the AND-gates 13 or 14 respectively have the level value L because of the level value L of the signal R.

Fig. 2 shows three subscribers 32^-, 32 and 32^+ which are connected by the optical conductor ring bus in schematic view in the manner shown in Fig. 1. In relation to the direction of signal flow, the subscriber 32^- is connected in front of subscriber 32_ and subscriber 32^+ is connected after the subscriber 32. Details of the subscribers 32^-, and 32 and 32^+ are provided by the reference symbols used in Fig. 1, while the details of the scribers 32^- and 32^+ are distinguished from each other by the addition of " − " or " + " respectively to the reference symbol. The optical signal ϕ_{A1}^- emitted by the light-emitting diode 27^- of the subscriber 32^- and the optical signal ϕ_{A2}^- of the optically parallel branch are supplied to the optical plug connection 28^- at the output of the subscriber 32^-. The arithmetic mean value of the optical

is assumed that this attenuation amounts to 1 dB. The optical signal which has been attenuated by 1 dB then subdivides into two signal parts ϕ_{E1} and ϕ_{E2} which are of equal size. The optical signal part ϕ_{E1} is supplied to the receiving part 5 which is associated with the electronic part 4 of the subscriber in Figs. 1 and 5. The receiving section 5 contains an opto-electronic converter 6 and an amplifier 7 which convert the optical signal part ϕ_{E1} into a proportional electrical voltage U_L. The electrical voltage U_L is supplied to a three state switch 8 and a delay element 9 which forms the arithmetic mean value U_{Lm} of the voltage U_L. The lower and upper thresholds of the three state switch 8 are designated U_{LuS} and U_{LoS} respectively. Both of the threshold values are in a fixed ratio to the arithmetic mean value, while one threshold value is smaller and the other larger than the arithmetic mean value. The two outputs of the three state switch 8 are connected to a circuit arrangement 12 via lines 10 and 11, the circuit arrangement 12 evaluating the information supplied to the subscriber. The signal on the line 10 is designated A_e and the signal on the line 11 is designated B_e, while their level values are designated either L or H. The three switching conditions of the three state switch 8 are shown in the following Table as a function of the voltage U_L:

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If the optical signal received is to be passed on, the signal R emitted by the circuit arrangement 12 has the level value H and the signal S has the level value L. The signals A_e and B_e are supplied via AND-gates 13 or 14 and OR-gates 15 or 16 to the control inputs of electronic switches 17 or 18 in this mode of operation. The signals A_s and B_s on the other hand are not passed on, since the output signal of the AND-gates 19 and 20 has the level value L because of the level value L of the signal S. The electronic switch 17 connects a first current source 21 to the transmission part 22 which in this case is assigned together with the receiving part 5 to the electronic part 4 of the subscriber. The electronic switch 18 connects a second current source 23 to the transmission part 22 and a third current source 24 is always connected to the transmission part 22. The electronic switch 17 is closed if the level value H is present at its control input and the electronic switch 18 is closed if the level value L is present at its control input. If the signals R and S have the level value L, then the electronic switch 17 is opened and the electronic switch 18 is closed.

The overall current I supplied to the transmission part 22 flows through the contact 25 of a relay 26 and through a light emitting diode 27 which produces an optical signal ϕ_{A1}, which corresponds to the overall current I which is flowing in each case and leads it via a further optical plug connection 28 into the outgoing end 29 of the optical conductor ring bus.

In the following it is assumed that in the optical plug connection 28 the signal is attenuated by 1 dB, as it is in the optical plug connection 2. The optical signal part ϕ_{E2} is supplied to the optical plug connection 28, via an optical connecting element 30 in the form of optical signal ϕ_{A2}. The optical signal ϕ_A in the outgoing end 29 of the optical conductor ring bus is formed by superimposing the optical signals ϕ_{A1} and ϕ_{A2} while taking the attenuation due to the optical plug connection 28 into account. In the case of faults in the electronic part 4 of the subscriber, a device 31 for detecting faults opens the contact 25 by means of the relay 26 and the optical signal ϕ_{A1} becomes zero.

If the subscriber is to operate in transmission, then the signal R emitted by the circuit arrangement 12 has the level value L and the signal S has the level value H. In this mode of operation, the signals A_s and B_s are supplied via the AND-gates 19 or 20 respectively and the OR-gates 15 or 16 respectively to the control inputs of the electronic switches 17 or 18 respectively. The signals A_e and B_e on the other hand are not passed on, since the output signals of the AND-gates 13 or 14 respectively have the level value L because of the level value L of the signal R.

Fig. 2 shows three subscribers 32^-, 32 and 32^+ which are connected by the optical conductor ring bus in schematic view in the manner shown in Fig. 1. In relation to the direction of signal flow, the subscriber 32^- is connected in front of subscriber 32 and subscriber 32^+ is connected after the subscriber 32. Details of the subscribers 32^-, and 32 and 32^+ are provided by the reference symbols used in Fig. 1, while the details of the scribers 32^- and 32^+ are distinguished from each other by the addition of " − " or " + " respectively to the reference symbol. The optical signal ϕ_{A1}^- emitted by the light-emitting diode 27^- of the subscriber 32^- and the optical signal ϕ_{A2}^- of the optically parallel branch are supplied to the optical plug connection 28^- at the output of the subscriber 32^-. The arithmetic mean value of the optical

signal ϕ_{A1}^- is selected to be four times as large as the arithmetic mean value of the optical signal ϕ_{A2}^- this ratio corresponds to an amplification of 6 dB as compared to the airthmetic mean value of the optical signal ϕ_{A2}^-. In the optical plug connection 28$^-$ the optical signal ϕ_{A1} and the optical signal ϕ_{A2}^- which is superimposed thereon experience attenuation of 1 dB. The optical output signal ϕ_A^- of the subscriber 32$^-$ is equal to the optical signal ϕ_E which is supplied to the subscriber 32 if it is assumed that the attenuation caused by the optical conductor 33 which connects the subscribers 32$^-$ and 32 is negligibly small. The optical signal ϕ_E experiences attenuation of 1 dB due to the optical plug connection 2, and there is a division of the output due to the subdivision into two signal parts of equal size of 3dB in each case and attenuation of 1 dB per branch which is caused by optical losses when dividing up the signal so that both the optical signal ϕ_{E1} and the optical signal ϕ_{E2} are attenuated by 6 dB in each case, as compared to the sum of the optical signals ϕ_{A1}^- and ϕ_{A2}^-. The optical signal ϕ_{E2} experiences attenuation of 1 dB due to the optical connection element 30 so that the optical signal ϕ_{A2} (which is superimposed on the optical signal ϕ_{A1} from the light-emitting diode 27) is attenuated as compared to the sum of the optical signals ϕ_{A1}^- and ϕ_{A2}^- by 7 dB. I.e., the arithmetic means value of the optical signal ϕ_{A2} is 20% of the sum of the aritimetic mean values of the optical signals ϕ_{A1}^- and ϕ_{A2}^-. Since the subscribers 32$^-$, 32 and 32$^+$ are similarly constructed, the arithmetic mean value of the optical signal emitted by the light emitting diodes 27$^-$, and 27 and 27$^+$ of all of the subscribers are of equal size. Thus the arithmetic mean value of the optical signal ϕ_{A2} is also attenuated by 6 dB as compared to the arithmetic mean value of the optical signal ϕ_{A1}. Therefore, the pre-condition is that the attenuation of the optical conductors connecting the subscribers should be negligibly small, e.g. because the subscribers are arranged close together. Since the light values are compared attenuation by 6 dB corresponds to a reduction by $\frac{1}{4}$ of the output value. The optical signal ϕ_A formed by adding the light values of signals ϕ_{A1} and ϕ_{A2} experiences attenuation of 1 dB in the optical plug connection 37 and of an additional 3 dB due to subdivision into two optical signal parts so that the optical signals ϕ_{E1}^+ is attenuated by 4 dB as compared to the optical signal ϕ_A.

Based on Fig. 2, Fig. 3 shows the optical signal ϕ_{A2}, the electrical voltage U_L which is proportional thereto and the optical signal ϕ_{A1} of the subscriber 32 as well as the optical signal ϕ_{A2}^+ and the voltage U_L^+ of the subscriber 32$^+$, which is proportional to the signal ϕ_{A2}^+ by way of line diagrams. The opto-electronic converter 6$^+$ of the subscriber 32′ converts the optical signal ϕ_{E1}^+ which has been supplied to it, into this voltage U_L^+. As described above, the arithmetic mean value of the optical signal ϕ_{A2} is attenuated by 8 dB as compared to the arithmetic mean value of the sum of the optical signals ϕ_{A1}^- and ϕ_{A2}^-; however it has the same time path qualitatively. Since the optical signal ϕ_{E1} and therefore the electrical voltage U_L, into which the opto-electronic converter 27 of the subscriber 32 converts the optical signal ϕ_{E1} associated therewith, have the same time path, the optical signal ϕ_{A2} and electrical voltage U_L are shown in a common curve in the upper line diagram of Fig. 3, the arithmetic mean values of which curve are designated either ϕ_{A2m} or U_{Lm} respectively. The optical signal ϕ_{A1} which has been regenerated by the electronic part 4 of the subscriber 32 is shown in the centre line diagram of Fig. 3. The values "0" and "1" of the binary variables which are to be transmitted are implemented by three level values ϕ_{A1u}, ϕ_{A1m} and ϕ_{A1o} which are of different magnitude, in which the level values ϕ_{A1o} and ϕ_{A1u} are the upper or lower values respectively of the optical signal ϕ_{A1} emitted by the light-emitting diode 27. If the difference between the optical signals ϕ_{A1o} and ϕ_{A1m} and between the optical signals ϕ_{A1m} and ϕ_{A1u} is designated $\Delta\phi_{A1}$ and if $\Delta\phi_{A1} = \alpha.\phi_{A1m}$, then the relationship $\phi_{A1o} = \phi_{A1m}(1 + \alpha)$ or $\phi_{A1u} = \phi_{A1m}(1 - \alpha)$ respectively are given for the upper and lower level values. In Fig. 3, $\alpha = {}^2/_3$ has been selected. The value "0" of the binary variable which is to be transmitted consists of three pulses of equal length each having the time duration Δt, the first of which has the level value ϕ_{A1u}, the second the level value ϕ_{A1o} and the third the level value ϕ_{A1m}. The value "1" of the binary variable which is to be transmitted comprises three pulses of equal length, each having the time duration Δt, the first of which has the level value ϕ_{A1o}, the second the level value ϕ_{A1u} and the third level value ϕ_{A1m}. During periods when no information is transmitted, $\phi_{A1} = \phi_{A1m}$. The optical signal ϕ_{A2}^+ and the voltage U_L^+ of the subscriber 32$^+$, which is proportional thereto, are shown in a common curve in the lower line diagram of Fig. 3.

The curve which is shown in the upper line diagram of Fig. 3, corresponds to the output signal of a subscriber which regenerates the received signal and passes the regenerated signal on while the attenuated non-regenerated signal is superimposed on the regenerated signal. The threshold values of the three-state switch 8 in relation to the arithmetic mean value U_{Lm} are selected as follows:

$$U_{LoS} = U_{Lm}\left(1 + \frac{\alpha}{2}\right) \text{ and } U_{LuS} = L_m\left(1 - \frac{\alpha}{2}\right).$$

$U_{LoS} = \frac{4}{3} U_{Lm}$ and $U_{LuS} = {}^2/_3 U_{Lm}$ are produced where $\alpha = {}^2/_3$.

At the point in time t_1 the voltage U_L exceeds the upper threshold values U_{LoS}. Once a processing time has expired, which time is due to the propagation times in the electronic part 4 of the subscriber 32, and is added to in

Fig. 3 by $\frac{\Delta t}{2}$, the optical signal ϕ_{A1}

(centre line diagram of Fig. 3) jumps from the level value ϕ_{A1m} to level value ϕ_{A1o} at the point in time

$$t_1' = t_1 + \frac{\Delta t}{2}.$$

At the point in time $t_1 + \Delta t$ the voltage U_L falls below the lower threshold value U_{LuS} and at the point in time

$$t_1' + \Delta t = t_1 + \frac{\Delta t}{2} + \Delta t$$

the optical signal ϕ_{A1} jumps from the level value ϕ_{A1o} to the level value ϕ_{A1u}. At the point in time $t_1 + 2\Delta t$ the voltage U_L exceeds the lower threshold value U_{LuS} but not the upper threshold value U_{LoS}.

Offset by $\frac{\Delta t}{2}$, the optical signal ϕ_{A1} jumps at the point in time

$$t_1' + 2\Delta t = t_1 + \frac{\Delta t}{2} + 2\Delta t$$

from the level value ϕ_{A1u} to the level value ϕ_{A1m}. At the point in time $t_2 = t_1 + 3\Delta t$, the voltage U_L falls below the lower threshold value U_{LuS} again and when offset by

$\frac{\Delta t}{2}$ the optical signal ϕ_{A1} jumps from the level value ϕ_{A1m}

to the level value ϕ_{A1u} at the point in time $t_2' = t_2 + \frac{\Delta t}{2}$.

The three pulses between points in time t_1 and t_2 or t_1' and t_2' respectively correspond to the value "1" of the binary variable which is to be transmitted. The three pulses between the points in time t_2 and t_3 or t_2' and t_3' correspond to the value "0" of the binary variable which is to be transmitted, and the three pulses between the points in time t_3 and t_4 or t_3' and t_4' correspond again to the value "1" of the binary variable to be transmitted.

The curve in the lower line diagram of Fig. 3 is formed from superimposition of the optical signals ϕ_{A2} and ϕ_{A1} while taking into account the attenuation due to the optical plug connections 28 and 2^+, the subdivision into optical signals $\phi_{E1}{}^+$ and $\phi_{E2}{}^+$ and the attenuation of the optical signal $\phi_{E2}{}^+$ in the optical attenuation element 30^+. As described above, the damping of the optical signals $\phi_{A2}{}^+$ is 7 dB as compared to the sum of the optical signals ϕ_{A1} and ϕ_{A2}, corresponding to a reduction by 20%. The threshold values related to the arithmetic mean value $U_{Lm}{}^+$ of the three-state switch in the electronic part of the subscriber 32^+ are selected as are those of the three-state switch in the electronic part of the subscriber 32:

$$U_{LoS}{}^{+} = U_{Lm}{}^{+}\left(1 + \frac{\alpha}{2}\right) \text{ and } U_{LuS}{}^{+} = U_{Lm}{}^{+}\left(1 - \frac{\alpha}{2}\right).$$

If, for example, the subscriber 32 has a fault, then the device 31 for detecting faults opens the contact 25 via the relay 26. The optical signal ϕ_{A1} is equal to zero and only the optical signal ϕ_{A2} is supplied to the subsequent subscriber 32^+. The arithmetic mean value $U_{Lm}{}^{+}$ is now in fact smaller than when there were no faults; since the threshold values $U_{LoS}{}^{+}$ and $U_{LuS}{}^{+}$ relate to the arithmetic mean value however, the electronic part of the subscriber 32^+ may also evaluate the electrical voltage $U_L{}^{+}$.

In Fig. 4, the case where two successive subscribers have interference is shown. The four schematically shown subscribers—as in Fig. 2—are provided with reference symbols 34, 35, 36, 37. The optical signal emitted by the subscriber 34, which signal is formed from superimposition of the regenerated optical signal and the attenuated optical signal which has been passed on directly is attenuated by 7dB in each of the two subscribers 35, 36 which have faults, since there is no regeneration. The optical signal received by the opto-electronic converter of the subscriber 37 is attenuated by 19 dB as compared to the optical signal emitted by the subscriber 34. Since the electrical part of each subscriber is designed for attenuating at least 28 dB optically, corresponding to 56 dB electrically, the losses on the optical conductors connecting the subscribers may amount to 9 dB overall. In the case of negligibly small losses on the optical conductors connecting the subscribers, the transmission system remains operational even if three successive subscribers have failed. With improvement of the electronic part of each subscriber, even better attenuation values can be achieved.

Fig. 5 shows a general view of a subscriber, the electronic part 4 of which corresponds to that of Fig. 1, its optical part 3' differing however, from the optical part 3 of Fig. 1. The optical part 3' contains an optical branch device, hereafter called a cross-coupler 38, to which two optical input lines 39 and 40 are applied. Two optical output lines 41 and 42 pass from the cross-coupler 38. The optical signal ϕ_{E1}' of the first line is attenuated by 1 dB as compared to the optical signal ϕ_E and it divides itself in half between the two optical output lines 41 and 42. From this subdivision of the optical signal, an attenuation of 3 dB arises and in addition there is an attenuation of 2 dB resulting from the optical losses due to two optical conductors meeting so that both the optical signal ϕ_{A1}' and the optical signal ϕ_{A2}' are damped by 5 dB as compared to the optical signal ϕ_{E1}'. The optical signal ϕ_{E2}' of the optical line 40 is only supplied to the optical line 41, i.e. not to the optical line 42. The optical signal ϕ_{A1}' is formed from superimposing the optical signal ϕ_{E1}' and ϕ_{E2}' while there is an attenuation of 5 dB at the transition to the optical line 41. A further attenuation which amounts to 1 dB occurs in the optical plug connection 28.

Fig. 6 shows three subscribers 43^-, 43 and 43^+ of the type shown in Fig. 5, connected by the optical conductor ring bus, in schematic view. Based on the attenuation values which were taken above, the arithmetic mean value of the regenerated optical signal ϕ_{E2}' is also 6 dB greater in this embodiment than the arithmetic mean value of the optical signal ϕ_{E1}'. When one subscriber fails, e.g. subscriber 43, the optical signal ϕ_{E2}' is equal to zero and the optical signal ϕ_A is attenuated by 7 dB as compared to the optical signal ϕ_E. Even with this embodiment, two successive subscribers may be faulty without interrupting the passage of the information which is to be transmitted. Attenuation of the optical signals ϕ_{E1}' and ϕ_{E2}' which are superimposed on each other on the path via the cross-coupler 38 to the plug connections 28 and 2^+ and the optical conductor connecting the subscribers 43 and 43^+ has to be at least 1 dB greater than the ratio between the light value of the optical signal $\phi_{E1}'^{+}$ and that of the optical signal $\phi_{E2}'^{+}$. Therefore, it is not important how the attenuation is distributed to the individual components. In the embodiments, an output ratio of 6 dB is assumed for the optical signals ϕ_{A1} and ϕ_{A2} (Figs. 1 to 4) or ϕ_{E2}' and ϕ_{E1}' (Figs. 5 and 6), which are superimposed on each other. Given this output ratio, the information to be transmitted may still be safely regenerated in the electrical part.

While in Fig. 1 the threshold values of the three-state switch 8 are automatically matched in the pulse shaper stage 44 to the height of the respective arithmetic mean value U_{Lm} of the electrical signal U_L, in Fig. 7 the electrical signal U_L is supplied to an automatically operating amplification control device 45. The delay element 9' forms the arithmetic mean value U_{Lmx}' of the output voltage U_L' of the amplification control device 45. The amplification control device 45 amplifies the electrical voltage U_L until the arithmetic mean value U_{Lmx}' of the voltage U_L' is equal to a predetermined fixed value U_{Lmw}'. The threshold values of the three-state switch 8' are set as follows:

$$U_{LoS}^{+} = U_{Lm}^{+}\left(1 + \frac{\alpha}{2}\right) \text{ and } U_{LuS}^{+} = U_{Lm}^{+}\left(1 - \frac{\alpha}{2}\right).$$

If, for example, the subscriber 32 has a fault, then the device 31 for detecting faults opens the contact 25 via the relay 26. The optical signal ϕ_{A1} is equal to zero and only the optical signal ϕ_{A2} is supplied to the subsequent subscriber 32^{+}. The arithmetic mean value U_{Lm}^{+} is now in fact smaller than when there were no faults; since the threshold values U_{LoS}^{+} and U_{LuS}^{+} relate to the arithmetic mean value however, the electronic part of the subscriber 32^{+} may also evaluate the electrical voltage U_L^{+}.

In Fig. 4, the case where two successive subscribers have interference is shown. The four schematically shown subscribers—as in Fig. 2—are provided with reference symbols 34, 35, 36, 37. The optical signal emitted by the subscriber 34, which signal is formed from superimposition of the regenerated optical signal and the attenuated optical signal which has been passed on directly is attenuated by 7dB in each of the two subscribers 35, 36 which have faults, since there is no regeneration. The optical signal received by the opto-electronic converter of the subscriber 37 is attenuated by 19 dB as compared to the optical signal emitted by the subscriber 34. Since the electrical part of each subscriber is designed for attenuating at least 28 dB optically, corresponding to 56 dB electrically, the losses on the optical conductors connecting the subscribers may amount to 9 dB overall. In the case of negligibly small losses on the optical conductors connecting the subscribers, the transmission system remains operational even if three successive subscribers have failed. With improvement of the electronic part of each subscriber, even better attenuation values can be achieved.

Fig. 5 shows a general view of a subscriber, the electronic part 4 of which corresponds to that of Fig. 1, its optical part 3* differing however, from the optical part 3 of Fig. 1. The optical part 3* contains an optical branch device, hereafter called a cross-coupler 38, to which two optical input lines 39 and 40 are applied. Two optical output lines 41 and 42 pass from the cross-coupler 38. The optical signal ϕ_{E1}' of the first line is attenuated by 1 dB as compared to the optical signal ϕ_E and it divides itself in half between the two optical output lines 41 and 42. From this subdivision of the optical signal, an attenuation of 3 dB arises and in addition there is an attenuation of 2 dB resulting from the optical losses due to two optical conductors meeting so that both the optical signal ϕ_{A1}' and the optical signal ϕ_{A2}' are damped by 5 dB as compared to the optical signal ϕ_{E1}'. The optical signal ϕ_{E2}' of the optical line 40 is only supplied to the optical line 41, i.e. not to the optical line 42. The optical signal ϕ_{A1}' is formed from superimposing the optical signal ϕ_{E1}' and ϕ_{E2}' while there is an attenuation of 5 dB at the transition to the optical line 41. A further attenuation which amounts to 1 dB occurs in the optical plug connection 28.

Fig. 6 shows three subscribers 43^{-}, 43 and 43^{+} of the type shown in Fig. 5, connected by the optical conductor ring bus, in schematic view. Based on the attenuation values which were taken above, the arithmetic mean value of the regenerated optical signal ϕ_{E2}' is also 6 dB greater in this embodiment than the arithmetic mean value of the optical signal ϕ_{E1}'. When one subscriber fails, e.g. subscriber 43, the optical signal ϕ_{E2}' is equal to zero and the optical signal ϕ_A is attenuated by 7 dB as compared to the optical signal ϕ_E. Even with this embodiment, two successive subscribers may be faulty without interrupting the passage of the information which is to be transmitted. Attenuation of the optical signals ϕ_{E1}' and ϕ_{E2}' which are superimposed on each other on the path via the cross-coupler 38 to the plug connections 28 and 2^{+} and the optical conductor connecting the subscribers 43 and 43^{+} has to be at least 1 dB greater than the ratio between the light value of the optical signal $\phi_{E1}'^{+}$ and that of the optical signal $\phi_{E2}'^{+}$. Therefore, it is not important how the attenuation is distributed to the individual components. In the embodiments, an output ratio of 6 dB is assumed for the optical signals ϕ_{A1} and ϕ_{A2} (Figs. 1 to 4) or ϕ_{E2}' and ϕ_{E1}' (Figs. 5 and 6), which are superimposed on each other. Given this output ratio, the information to be transmitted may still be safely regenerated in the electrical part.

While in Fig. 1 the threshold values of the three-state switch 8 are automatically matched in the pulse shaper stage 44 to the height of the respective arithmetic mean value U_{Lm} of the electrical signal U_L, in Fig. 7 the electrical signal U_L is supplied to an automatically operating amplification control device 45. The delay element 9* forms the arithmetic mean value U_{Lmx}^{*} of the output voltage U_L^{*} of the amplification control device 45. The amplification control device 45 amplifies the electrical voltage U_L until the arithmetic mean value U_{Lmx}' of the voltage U_L' is equal to a predetermined fixed value U_{Lmw}'. The threshold values of the three-state switch 8* are set as follows:

value of the electrical signal to a predetermined fixed value.

6. A transmission system according to any one of the preceding claims, wherein the transmitting subscriber does not continue to regenerate the information supplied back to it after the information which is to be transmitted has completed one circuit of the ring.

7. An opto-electronic transmission system with several subscribers coupled to an optical conductor ring bus, each subscriber having an optical branching device for dividing the incoming optical signal into two portions, a receiving part for converting one of the two portions into an electrical signal, a pulse shaper for regenerating the electrical signal and a transmission part for converting the regenerated electrical signal into an optical signal and supplying the optical signal to the optical conductor ring bus for passing to the next subscriber, wherein the optical branching device attenuates the other signal portion and superimposes it on the optical signal transmitted by the transmission part.

8. A transmission system according to claim 7, wherein the transmitted information is coded in a code with three switching states with a constant arithmetic mean value and the pulse shaper comprises the electrical signal from the receiving part with two threshold values, one of which is larger and the other smaller than the mean value of the electrical signal and both having a constant ratio with the mean value.

9. An opto-electronic transmission system substantially as decribed herein with reference to the drawings.

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